Stopping corrosion on in-service structures

Unlike more traditional coatings, chemically bonded phosphate ceramics can stop corrosion, extend equipment life, and minimise production downtime

MERRICK ALPERT
EonCoat

Operations managers and corrosion engineers are finding that one of the best ways to cut costs and maintain income levels is to eliminate the ongoing costs associated with corrosion control on in-service structures made of carbon steel.

According to the NACE International report *Corrosion Costs and Preventive Strategies in the United States*, for gas and liquid transmission pipelines alone, "The average annual corrosion-related cost is estimated at $7 billion to monitor, replace, and maintain these assets." This figure quickly multiplies when lost revenue, productivity, and spill or leak clean-up costs are tallied – a hit to the bottom line that the industry struggles to endure when oil and gas prices are low.

From upstream transit containers to midstream product transport, storage, and processing, to downstream refining, the challenge has long been to control corrosion on carbon steel service structures. Traditionally, polymer paints and rubber type coatings have been used as physical barriers to keep corrosion promoters such as water and oxygen away from steel substrates. This works until the paint is scratched, chipped, or breached and corrosion promoters enter the gap between the substrate and coating.

Then the coating can act like a greenhouse – trapping water, oxygen and other corrosion promoters – which allows the corrosion to spread. For this reason, such coatings are often reapplied every three to seven years, depending on factors such as rainfall, humidity, and proximity to a marine environment. While stainless steel can be used for tanks or other high-value equipment to resist corrosion, it can be up to six times more costly than carbon steel, as well as challenging to weld, fabricate, and maintain.

Figure 1 Chemically bonded phosphate ceramics provide an anti-corrosion coating for carbon steel pipes

Stainless steel can be up to six times more costly than carbon steel, as well as challenging to weld, fabricate, and maintain

A new generation of anti-corrosion coating, called chemically bonded phosphate ceramics, is able to cost-effectively stop such corrosion, improve safety, and extend tank, pipeline and equipment life in the oil and gas industry while minimising maintenance and downtime.

Case study

With total assets and annual sales revenue of over RMB 10 billion ($1.5 billion), the Energy Development LLC of China National Offshore Oil Corporation (EDC of CNOOC) sought to protect its offshore platform transit containers from corrosion. But because of year-round exposure to marine conditions, as well as severe collisions due to repeated hoisting and transport, traditional coatings failed rapidly after being put into service. In addition, such coatings had other drawbacks during application: they inefficiently

Figure 2 The ceramic shell acts as a reservoir of phosphate to continually re-alloy the steel

required multiple coats, were toxic, flammable, and emitted VOCs.

To address these issues, the company turned to EonCoat, a spray applied inorganic coating from the Raleigh, North Carolina based company of the same name. EonCoat represents a new category of tough, chemically bonded phosphate ceramics (CBPCs) that can stop corrosion, ease application, and reduce production downtime.

In contrast to traditional polymer coatings that sit on top of the substrate, the corrosion resistant CBPC coating bonds through a chemical reaction with the substrate, and slight surface oxidation actually improves the reaction. An alloy layer is formed. This makes it impossible for corrosion promoters like oxygen and humidity to get behind the coating the way they can with ordinary paints.

Although traditional polymer coatings mechanically bond to substrates that have been extensively prepared, if gouged, moisture and oxygen will migrate under the coating's film from all sides of the gouge.

By contrast, the same damage to the ceramic coated substrate will not spread corrosion in oil and gas facilities because the carbon steel's surface is turned into an alloy of stable oxides. Once the steel's surface is stable (the way noble metals like gold and silver are stable) it will no longer react with the environment and cannot corrode.

Viewed by means of scanning electron microscopy, EonCoat does not leave a gap between the steel and the coating because the bond is chemical rather than mechanical. Since there is no gap, even if moisture were to get through to the steel due to a gouge, there is nowhere for the moisture to travel, which effectively stops corrosion.

EonCoat does not leave a gap between the steel and the coating because the bond is chemical rather than mechanical

The corrosion barrier is covered by a ceramic shell that resists corrosion, fire, water, abrasion, impact, chemicals, and temperatures up to 400°F (204°C). Beyond this, the ceramic shell serves a role that helps to end the costly maintenance cycle of replacing typical barrier type coatings every few years.

If the ceramic shell and alloy layer is ever breached, the ceramic shell acts as a reservoir of phosphate to continually re-alloy the steel. This self-heals the breach, depending on its size, and stops the corrosion if necessary. This capability, along with the coating's other properties, enables effective corrosion protection for the life of in-service structures with a single application.

For such corrosion protection, Wuhan Hengshi Engineering spray applied EonCoat to 38 containers that were put into service for EDC of CNOOC, covering about 1837 m^2 in total. Over three years later the containers indicate excellent corrosion protection, except for a few areas of coating fall-out due to container collision. These areas were quickly repaired and the units put back into service.

When equipment like containers is roughly handled to the point where the steel and surrounding CBPC coating are damaged, the coating can typically be repaired by spraying a new layer of EonCoat over the old one, provided any chipped edge is abraded to a smooth transition. Because of this, equipment can be returned to service in a matter of hours if the company has the spray equipment on-site.

Oil and gas operation managers or corrosion engineers looking to reduce costs are finding additional advantages to CBPC coatings like EonCoat beyond corrosion resistance.

Such coatings consist of two non-hazardous components that do not interact until applied by a standard industrial plural spray system like those commonly used to apply polyurethane foam or polyurea coatings. Since CBPC coatings are inorganic and non-toxic, there are no VOCs, no HAPs and no odour. This means the non-flammable coatings can be applied safely even in confined spaces.

One of the major benefits, however, is a quick return to service that minimises facility downtime. The time saved on an anti-corrosion coating project with the ceramic coating comes both from simplified surface preparation and expedited curing time. With a typical corrosion coating, near white metal blast cleaning (NACE 2/SSPC-SP 10) is required to prepare the surface. But with the ceramic coating, only a NACE 3/SSPC-SP 6 commercial blast cleaning is typically necessary.

For corrosion protection projects using typical polymer paints such as polyurethanes or epoxies, the cure time may be days or weeks before the next coat of traditional 'three part systems' can be applied, depending on the product. The cure time is necessary to allow each coat to achieve its full properties, even though it may feel dry to the touch.

With traditional coatings, extensive surface preparation is required and done a little at a time to avoid surface oxidation, commonly known as 'flash rust', which can require re-blasting.

Typically you need to keep an SP 10 standard preparation throughout the entire blast operation, cleaning operation, and painting operation with traditional coatings; humidity above 60% will oxidise the surface and require re-blasting.

In contrast, a corrosion resistant coating for carbon steel utilising the ceramic coating in a single coat requires almost no curing time. Return to service can be achieved in as little as one hour. This kind of speed in getting an asset producing again can potentially save hundreds of thousands of dollars per day in reduced downtime in oil and gas applications.

You can blast the entire surface, then coat it with EonCoat without concern over losing an acceptable blast. There is no need for specialist equipment because the ceramic coating can be applied when it is wet or humid. A little surface oxidation makes it adhere better.

Hydrocarbons are the number one cause of coating delamination at petrochemical facilities. To avoid coating delamination at refineries with traditional coatings, all hydrocarbons such as oil and grease must be found by black light methods, then removed by chloriding until black light passes. This is not required with the ceramic coating because it will not adhere to hydrocarbons, so on surfaces that are not clean the coating will 'bubble' on the poorly prepared substrate.

You can immediately identify and correct poor surface preparation during application. For quality assurance, you can also take the coating's dry film thickness as early as 15 minutes after application at 75°F (24°C). That means the coating can be performed and corrected at the same time, which makes work quicker and gives a more predictable outcome.

Merrick Alpert is President of EonCoat, LLC, a coatings company.